ClO_4^-). Thus, the complex where L = ½ en is inactive. Salts of analogous complexes of the type *trans*$[Mpy_4Cl_2]^+$ (M = Co^{III} or Ir^{III}) are inactive. This suggests that the effect in the rhodium cases is not merely that of a cation of particular charge and shape since many complexes $[Mpy_4X_2]Y$ (M = Co, Rh or Ir) are isomorphous.

The mechanism of this antibacterial action of *trans*$[Rh(py\text{-}X)_4Cl_2]^+$ is being studied. The fact that the property is so specific to compounds of this structure offers a clue. We have already suggested that the other property which is highly specific to these particular rhodium complexes is their redox behaviour, and it seems likely that the biological activity may be related to this.

There is some evidence that this is so from observations on the culture of *Escherichia coli* with sub-lethal amounts of *trans*$[Rhpy_4Cl_2]^+$. Further, the rhodium(III) pyridine complexes, polarographically, have $E_{\frac{1}{2}} \sim -100$ to -200 mV, whereas the biologically inactive complexes *trans*$[Rhen_2Cl_2]^+$ and *trans*$[Rhen_2Br_2]^+$ have $E_{\frac{1}{2}}$ -700 and -500 mV respectively.

The chemistry of complexes of rhodium with aromatic nitrogen donors was apparently well understood thirty years ago. In 1957, Delepine's actual samples were used in the first application of ligand field theory to rhodium complexes, and it then seemed likely that further effort in this area would be barren. Striking developments have occurred in the past five or six years, and I hope that it will be clear from the present treatment that it is not necessary to invent new ligands to obtain surprising and thought-provoking results in the chemistry of these fascinating elements.

References

1 W. P. Griffith, The Chemistry of the Rarer Platinum Metals, John Wiley, 1967
2 B. D. Faithful and S. C. Wallwork, *Chem. Comm.*, 1967, 1211
3 G. C. Dobinson, R. Mason and D. Russell, *Chem. Comm.*, 1967, 209
4 R. D. Gillard and G. Wilkinson, *J. Chem. Soc.*, 1964, 1224
5 P. Anderson, J. Josephsen, G. Nord, C. E. Schaffer, and R. L. Tranter, *Chem. Comm.*, 1969, 408, and references therein
6 R. D. Gillard, J. A. Osborn and G. Wilkinson, *J. Chem. Soc.*, 1965, 1951, and references therein

Palladium-Silver Resistor Pastes

EFFECT OF FIRING CONDITIONS ON ELECTRICAL PERFORMANCE

Complex reactions occur when silver-palladium resistor pastes are fired in the preparation of thick film circuits. Some light was shed on these in a paper by P. H. Krahl and A. F. Bogenschütz of the Research Institute of Allgemeinen Electricitätsgesellschaft, AEG-Telefunken, Ulm (*Metall*, 1968, **22**, (10), 988) and reviewed in *Platinum Metals Review*, 1968, **13**, (1), 30. The same authors have now investigated the effect of firing conditions on the electrical properties of the resistors (*Metall*, 1970, **24**, (2), 118-122).

The authors used two Du Pont pastes based on silver-palladium and silver-palladium oxide, and a three-zone kiln with independent zone control. The effects of firing time and temperature were investigated independently using controlled atmospheres of air and oxygen.

Their results show that the firing temperature, cycle and atmosphere strongly influence the electrical properties of the resistors, mainly because of variations in the degree of oxidation of Pd and reduction of PdO, and in the degree of fusion of the glass frit vehicle in which the metal and oxide powders are dispersed. Under no single set of conditions were optimum values obtained for all of: reproducibility of resistance values, temperature coefficient of resistance, low electrical noise, and long-term stability.

The authors recommend that because it is difficult to predict the behaviour of the pastes, firing tests should always be carried out to establish the most suitable conditions. They obtained their most favourable results using a 30 to 40 minute cycle, and temperatures of 680°C and 780°C respectively for the Pd and PdO based resistors, claiming reproducible resistances with a scatter of ± 10 per cent of the mean values by rigid adherence to these conditions.

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